Appendix J4
Geotechnical Desktop Study

Project Title:	Subject:
CABRILLO PORT PIPELINE SHORELINE CROSSING	**Geotechnical Desktop Study**

CONFIDENTIAL

GEOTECHNICAL DESKTOP STUDY, CABRILLO PORT PIPELINE SHORELINE CROSSING, VENTURA COUNTY, CALIFORNIA

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Project No. 3390.002 Task 07

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Attention: Steven R. Meheen

Subject: Geotechnical Desktop Study, Cabrillo Port Pipeline Shoreline Crossing, Ventura County, California

Fugro is pleased to present this desktop study report summarizing the anticipated geologic conditions at the planned pipeline shore crossing location for BHP Billiton's (BHP) proposed Cabrillo Port project. The planned pipeline shore crossing is to pass beneath Ormond Beach using horizontal directional drill (HDD) techniques.

The current report summarizes various historical geologic data within several miles on either side of the beach in the area bounded by Port Hueneme to the northwest and Point Mugu to the southeast. Synthesis and use of the various data allow us to conclude that the subsurface conditions encountered in a preliminary deep boring drilled for the proposed HDD shore crossing should generally reflect the character and conditions of the subsurface sediments along the planned HDD alignment.

The scope of work for the shore crossing desktop study was discussed with Mr. Vaughan Humphreys with BHP. Authorization to proceed was provided by receipt of BHP Master Services, Service Order No. 1 to the Prime Contract from BHP, dated January 1, 2005.

Thank you for the opportunity to provide geotechnical services to BHP Billiton for the proposed Cabrillo Port project. Please call if you have any questions on the information presented herein.

Sincerely,

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE OF DESKTOP STUDY

This desktop study report summarizes the geologic conditions within the beachfront environment of the project area relative to the planned pipeline shore crossing location of the two pipelines for the BHP Billiton's (BHP) proposed Cabrillo Port project. The planned pipeline shore crossings are to pass beneath Ormond Beach using horizontal directional drill (HDD) techniques. The project includes construction of HDD installed pipelines that will originate onshore near the beachfront and extend offshore about 1.3 kilometers where the will exit onto the seafloor at about the El. –13.7 meter (-45-foot) isobath. At this time, two alternate locations near the beachfront are being considered for initiation of the HDD bores. The optional locations under consideration are within the Reliant Energy power plant and the U.S. Navy Point Mugu facility (Plate 1 – Project Location).

The purpose of the pipeline shore crossing desktop study is to provide preliminary subsurface geotechnical information near the beachfront environment as input toward California State Lands Commission (CSLC) and California Coastal Commission (CCC) permitting requirements. This report is not intended for use in final design or construction. Additional geotechnical studies, reports, and services will be needed if the project proceeds to design or construction.

This report summarizes various onshore and offshore historical geologic data within several miles of the proposed HDD alignment. The general study area extends from an area bounded by Port Hueneme to the northwest and Point Mugu to the southeast, inland about 4 kilometers, and offshore about 3 kilometers. Synthesis of the various data within the desktop study area demonstrates that the subsurface conditions encountered in a preliminary deep boring drilled on Southland Sod Farms property (Plate 2 – Data Location Map) for the proposed HDD shore crossing are representative of the character and conditions of the subsurface sediments anticipated along the planned HDD alignment.

1.2 CABRILLO PORT PROJECT DESCRIPTION

The proposed Cabrillo Port LNG Terminal is to be located offshore Ventura County to the south of Mugu Rock. From the offshore terminal, the natural gas will be transported via twin 24-inch-diameter pipelines to the Ventura County coast. The pipelines will cross beneath the beach and come onshore to the south of Ormond Beach. The pipelines will be constructed beneath the shoreline using HDD techniques.

At this time, two locations near the beachfront are being considered for initiation of the HDD bores. The locations under consideration are the Reliant Energy power plant and the U.S. Navy Point Mugu facility, north of Laguna Point (Plate 1). Landward of the HDD initiation site, the pipelines will tie into the Southern California Gas Company's distribution system about 400 to 700 meters inland from the HDD initiation site. The proposed HDD bores will extend offshore

from the initiation point about 1.3 kilometers and exit onto the seafloor at about the El. –13.7m isobath (-45-feet).

The preliminary profile of the proposed HHD alignment is shown on Plate 3 – Preliminary HDD Profile. As shown, the bores are to deviate down from their onshore entrance until about El. -24.4 meters (-80 feet) Mean Lower Low Water (MLLW) datum. From about El. –24.4 meters, the bores will extend near horizontally until they are about 75 meters short of their exit point. From this point, the HDD bores will curve upwards until the bores daylight into a transition trench at the end of the alignment.

Additional description of the proposed pipeline shore crossing and HDD bore is contained in three reports prepared for BHP:

- *Drilling Fluid Release Monitoring Plan for Horizontal Directional Drilling*, report prepared by Brungardt Honomichi & Co. (BHP Document No. WCLNG-BHP-DEO-TX-00-001-0),
- *Preliminary Construction Procedure and Design for Horizontally Directionally Drilled Pipeline Landfall*, report prepared by John D. Hair. (BHP Document No. WCLNG-BHP-DEO-TP-00-001-0), and
- *HDD Nearshore Pipeline Project Marine Operations*, report prepared by Marine Project Management, Inc. (BHP Document No. WCLNG-BHP-DEO-TX-00-002-0).

1.3 PREVIOUS PROJECT - RELATED STUDIES BY FUGRO

The Fugro group of companies have previously conducted the following studies for the proposed BHP Cabrillo Port Project:

- Fugro Pelagos, Inc. performed a geophysical survey to identify geologic and man-made hazards and constraints for the offshore pipeline route and anchorage area of BHP Cabrillo Port project between June 2003 and January 2004 (Fugro Pelagos, 2004). The Geophysical Survey Report (FPI, 2004a) presents geologic and geotechnical conditions that could potentially affect the pipeline alignment and anchorage sites, including proximity to known existing faults, potential for strong ground shaking and fault rupture, project topography, and geomorphology of the sea floor.
- In the spring 2004, Fugro West, Inc. completed a preliminary assessment (Fugro West, 2004) geologic hazards that could affect or be affected by the project. Subsurface exploration was not performed as part of that study.
- In February-March 2005, Fugro West, Inc. conducted a preliminary subsurface investigation (Fugro West, 2005) for the onshore portion of the proposed shoreline crossing. To maximize the usefulness of the deep drill hole advanced for the

preliminary investigation, it was located about midway between the two alternate HDD initiation sites (Plate 2).

1.4 AUTHORIZATION

The scope of work performed for this desktop study was based on discussions with Mr. Vaughan Humphreys with BHP and an April 7, 2005 email from Mr. Humphreys. The desktop study was authorized by BHP Master Services Service Order No. 1 to the Prime Contract from BHP dated January 1, 2005.

2.0 GEOLOGIC DATA

2.1 GEOLOGIC DATA SOURCES

We reviewed readily available published geologic maps, selected geotechnical data, and selected published geologic reports for the desktop study area. The following sources were reviewed to obtain subsurface data and geological interpretations of the conditions in the study area:

- Regional geologic maps
  - Onshore geologic mapping by Clahan (2003), Tan and Clahan (2004), and Tan, Clahan, and Hitchcock (2004),
  - Offshore geologic mapping by United States Geological Survey (1987), and
  - Historical soils maps by US Department of Agriculture, Bureau of Soils, (1917)
- Geologic reports related to Oxnard Plain groundwater systems
- Site-specific geotechnical reports and data in the study area, including unpublished geotechnical reports for projects:
  - at the Port of Hueneme,
  - in the industrial area to the southwest of Saviers Road and Hueneme Road,
  - at Ormond Beach,
  - in the Silverstrand Beach area (northwest of Port Hueneme),
  - in the U.S. Navy's Point Mugu facility, and
  - elsewhere on the Oxnard Plain.
- Site-specific subsurface exploration data (copies of the logs for those explorations are included in Appendix A of this report) collected during prior preliminary studies for the BHP Cabrillo Port project including:

- The 61-meter (200-foot) deep onshore drill hole advanced on the Southland Sod Farms property,
- Four, approximately 4.5-meter (15-foot) penetration, closely-spaced vibracores advanced at about the –14-meter (-45-foot) isobath, approximately 1 kilometer (3,000 feet) offshore from Ormond Beach, and
- Five surface grab or drop core samples collected from the seafloor within about 5 kilometers offshore from the coast.

2.2 GEOLOGIC MAPS AND PROFILES

The geologic references and data have been synthesized to prepare the following maps included in this report:

- Plate 2 – Data Location Map – Areas where Fugro has obtained factual subsurface drill hole and cone penetration test sounding data available in our project files.
- Plate 3 – Preliminary HDD Profile – Preliminary HDD profile generated by Hair, (2005) annotated with sod farm boring log and composite vibracore log.
- Plate 4 – Geology Map. Combines the onshore geologic mapping of Clahan (2003), Tan and Clahan (2004), and Tan, Clahan, and Hitchcock (2004), with the offshore geologic mapping of USGS (1987). The map shows the distribution of the various surficial geologic units and the locations of known faults within the project area.
- Plate 5 - 1917 Soils Map. The US Department of Agriculture, Bureau of Soils shows the distribution of the onshore surficial sediments in the study area, the surface geomorphology, and lagoonal/marsh areas of the coastal strip prior to extensive development.
- Plate 6 – Generalized Geologic Cross Sections. These geologic cross sections are: reproduced from USGS (2003), based on their interpretation of water well logs, and show the interpreted geologic stratigraphy down to several hundreds of meters depth. One cross section (E-E') is oriented roughly parallel to the shoreline in the project area and two cross sections are oriented roughly perpendicular to the shoreline. The perpendicular cross-sections have been constructed through Port Hueneme (C-C') and to the west of Pt. Mugu (D-D').
- Plates 7 through 10 – Subsurface Profiles. These subsurface profiles have been constructed using historical geotechnical subsurface exploration data available from the references and Fugro files depict the interpreted subsurface sediment types down to about 70-meters depth. The locations of the four subsurface profiles are shown on Plate 2. Profile 1-1' (shown on Plate 7) extends northwest – southeast along the coast from the Port Hueneme Harbor to Point Mugu, while Profiles 2 – 2' through 4 – 4' (Plates 8 through 10) extend perpendicular to the

beach. A key to the symbolism used on the subsurface profiles is provided on Plate 11.

Three of the subsurface profiles interpreted from historical geotechnical exploration data approximately correlate to the three USGS geologic cross sections interpreted from water well logs. The correlation between the detail presented by the subsurface profiles and the USGS geologic cross sections is as follows:

- Coastline Parallel: Subsurface Profile 1-1' and USGS Cross Section E-E'
- Coast Perpendicular:
  - Through Port Hueneme: Subsurface Profile 2-2' and USGS Cross Section C-C'
  - West of Point Mugu: Subsurface Profile 4-4' and USGS Cross Section D-D'

3.0 GEOLOGIC CONDITIONS

3.1 REGIONAL GEOLOGIC SETTING

The proposed HDD bore component of the pipeline alignment is located within the western Transverse Ranges geologic/geomorphic province of California. That province is characterized by generally east-west trending mountain ranges composed of sedimentary and volcanic rocks ranging in age from Cretaceous to Recent.

The western Transverse Ranges province of Southern California is characterized by east-west trending folds and faults, which contrast with the regional northwest-southeast structural trend that predominate in the Peninsular Ranges and the California Continental Borderland. The different structural trend of the western Transverse Ranges results from the convergence created by the "big bend" of the San Andreas fault at the northeastern limit of the province. Major east-trending folds, reverse faults, and left-lateral strike-slip faults reflect regional north-south compression and are characteristic of the Transverse Ranges.

The proposed shoreline crossing location is within the southwestern part of the Oxnard Plain (Plate 1). The onshore Oxnard Plain and Santa Clara River Valley together with the adjacent offshore Ventura Mainland Shelf and Santa Barbara Channel form the Ventura Basin, which is the dominant structural element of the western Transverse Ranges. The Ventura Basin is an elongated depression that bisects the Transverse Ranges between Point Conception and the San Gabriel fault. The basin is bounded on the north by the Santa Ynez Mountains and on the south by the Santa Barbara Channel Islands. To the west, the basin merges with the Santa Maria basin. The Ventura basin is filled with a thick sequence of Cenozoic sedimentary rocks estimated to be more than 6,100 meters (20,000 feet) in total thickness.

The Oxnard Plain and Ventura Mainland Shelf is a prograding delta that resulting from the deposition of sediments transported to the coast by the Ventura and Santa Clara Rivers.

The Santa Clara River is the largest river in Southern California in terms of discharge and suspended sediment load, and is the largest source of sediment to the area. During periods of lowered sea levels, these two large rivers crossed the exposed delta and transported sediments directly to the shelf edge.

Both the Ventura and Santa Clara Rivers have migrated or avulsed across the coastal plain and shelf through geologic time. Geologic evidence suggests that the Santa Clara River has migrated as far south as the Hueneme Canyon during periods of lowered sea level in the Late Pleistocene (Dahlen, 1992).

3.2 FAULTING

Although faulting is common in the western Transverse Ranges, the proposed HDD shore crossing alignments are not underlain any known faults. As shown on Plate 4 – Geology Map, the nearest potentially active or known active faults are at least 3 to 4 kilometers from the proposed shore crossing area.

3.3 LOCAL GEOMORPHOLOGY AND COASTAL PROCESSES

3.3.1 Geomorphology

The proposed HDD bore initiation sites are located in the Ormond Beach area of the Oxnard Plain. Ormond Beach is about the mid-point of a 10.5-kilometer long section of coastline that trends northwest-southeast at a relatively uniform azimuth of 310 degrees. This southwest facing section of coast extends from what is now Port Hueneme to about 4 kilometers northwest of Point Mugu.

USGS topographic maps of the project vicinity indicate that the surface topography in the Ormond Beach area is relatively flat and is characterized by a very gentle slope of less than 1 percent to the southwest. In the immediate area of Ormond Beach, the drainage is generally towards the coast via a series of small drainages. The largest drainage in the desktop study area is Calleguas Creek, which is located along the eastern margin of the Oxnard Plain, adjacent to the Santa Monica Mountains, and drains to the ocean northwest of Point Mugu.

As shown on the 1917 soils map (Plate 5), the predevelopment geomorphology along this section of coast included coastal dunes and backdune lagoons. The largest lagoonal areas existed at the northwestern and southeastern boundaries of this section of southwest facing coastline. As shown on Plate 5, the Hueneme and Mugu lagoons are immediately inland of the offshore Hueneme and Mugu Canyons. This suggests that those lagoons were remnants of major drainage systems that were active during historical periods of sea level low stands, when sea level was as much as 350 feet lower than present. Whereas, Mugu lagoon is still a major geomorphic feature, most of the former Hueneme lagoon has been excavated to develop the Port of Hueneme or has been filled for development.

The 1917 Soils Map (Plate 5) shows that the predevelopment geomorphology of the southwest facing coastline between the Hueneme and Mugu lagoons included a series of at least five smaller lagoons or wetlands. Two of these predevelopment lagoons were present to the northwest and southeast of the Reliant Energy power plant. The proposed HDD alignment that originates at the Reliant Energy power plant appears to be between those two historical lagoonal areas. Another one of the historical lagoonal areas was located near what is currently the northwestern limit of the U.S. Navy Point Mugu facility. The proposed HDD alignment that originates in this property appears to be very close to the edge of the lagoon.

3.3.2 Coastal Processes

Littoral currents produce southeast movement of the beach sediments along northwest–southeast trending coastline. Construction of Hueneme Harbor and its associated jetties in the 1930s to 1950s has disrupted the natural downcoast movement of the beach sediments. The interruption of the littoral movement of the sediments has caused severe coastal erosion downcoast from Hueneme Harbor. Currently, the sediments that accumulate upcoast of the Hueneme Harbor jetty are bypassed biannually to replenish the downcoast beaches. The proposed HDD shore crossing locations, however, are downcoast of the area affected by the beach erosion.

In the last few decades, the coastward erosion of the heads of the Mugu Canyon system has begun to affect the coastal process to the southeast of the proposed HDD shoreline crossings. As the heads of the Mugu Canyon system have eroded and regressed, the canyons have begun to capture increasing percentages of the sediment moved downcoast by the littoral currents. As these sediments have begun to be transported down into the canyon system, the headward retreat of the canyons has increased. In the early 1990s, a small jetty and one building on the sand beach at Mugu were destroyed by waves from winter storms.

3.4 OFFSHORE BATHYMETRY AND SEAFLOOR CONDITIONS

The shallow seafloor shelf extends about 8 kilometers offshore from Ormond Beach, to a water depth of about 50 meters. Except for the areas adjacent to the Hueneme and Mugu Canyon systems, the seafloor generally slopes to the southwest. Within a kilometer of the beach, the seafloor slope is between ½ and 1 degree. Farther offshore, the seafloor slope is more typically between ¼ and ½ degree.

Offshore from Ormond Beach, the seafloor is generally featureless, although the sidescan sonar records show areas that apparently include scattered small debris and/or small rocks. No large seafloor anomalies were noted on the sidescan sonar records within the more than 1-kilometer-wide survey corridor, offshore from the Reliant Energy power plant.

The character of the sidescan sonar records, as well as the grab, drop core, and vibracore samples, suggest that the seafloor is generally underlain by dense sand out to about 25 meters water depth. The sampling suggests that the sand is typically fine-grained, although

the sidescan sonar records suggest coarser sand or fine gravel may be present on the seafloor in some local areas. Farther offshore, the seafloor shelf includes areas of sandy silt and silty sand.

3.5 STRATIGRAPHIC SEQUENCE

3.5.1 General Description

In the Ormond Beach area, as in other low-lying, near-coastal deltaic areas, the subsurface stratigraphy can consist of interbedded or coalesced alluvial sediments, marine sediments, and/or lagoonal sediments. As described below, interpretation of water well logs by the USGS (2003), suggests that the various geologic units underlying the area are of relatively constant thickness. However, due to the alluvial and lenticular nature of the deposits, individual sediment lithologic layers within each geologic unit units may be of variable thickness and may not be laterally continuous.

Several authors have mapped the Oxnard Plain area including Weber, et. al. (1973), US Geological Survey (USGS, 2003), California Geological Survey (CGS, 2002), Turner (1977), Clahan (2003), Tan and Clahan (2000), and Tan, Clahan, and Hitchcock (2004). Weber et al. (1973) interprets that much of the Oxnard Plain is underlain by deltaic alluvial deposits that consist primarily of clayey to silty sand. Weber also indicates that Ormond Beach is underlain by beach and dune sand and that lagoonal deposits are located in the vicinity of the Reliant Energy and U. S. Navy sites. The CGS (2003) indicates that the sediment within the upper 13 meters (40 feet) of the surface generally consists of alternating beds of sand, gravel, silt, and clay typical of basin alluviation, and that loose sand and silty sand layers are particularly abundant in near-surface deposits throughout the Oxnard plain to the south of the Santa Clara River.

3.5.2 Hydrogeologic Conditions

The groundwater hydrology beneath the Oxnard Plain has been summarized in reports by USGS (2003), CGS (2002), and Turner (1975). According to the USGS (2003), the groundwater system within the Oxnard Plain consists of an upper- and lower-aquifer.

The upper-aquifer system is composed of unconsolidated alluvial deposits of Pleistocene to Holocene age that reach depths of about 18 to 24 meters (150 to 250 feet) below land surface throughout most of the Oxnard Plain and extend offshore within the continental shelf (Plate 6). The upper-aquifer system is subdivided into the shallow aquifer and the Oxnard aquifer. The shallow aquifer is an unconfined aquifer that extends to a depth of about 21 meters (70 feet) and is separated from the underlying Oxnard aquifer by a clay-rich horizon. The Oxnard aquifer extends to depths of about 45 to 76 meters (150 to 250 feet) depth, comprises the base of the Holocene deposits, and consists of sand and gravel deposited by the ancestral Santa Clara River and Calleguas Creek.

The CGS (2002) indicates that the shallow groundwater elevation within the Oxnard plain has been relatively consistent historically, averaging about 2 meters (6 feet) over much of the Plain to sea level near the coast. Groundwater recharge in the Oxnard Plain is predominately from surface and subsurface flow from the Santa Clara River.

3.5.3 Geologic Cross Sections

The generalized geologic cross sections, (Plate 6) interpreted by the USGS (2003) indicate that in the desktop study area, the Oxnard Plain is underlain (in descending sequence) by:

- About 30 to 33.5 meters (100 to 110 feet) of Recent Alluvium,
- About 29 to 36.5 meters (95 to 120 feet) of Submarine Shelf Deposits,
- About 49 to 70 meters (160 to 230 feet) of Upper Pleistocene Deposits,
- About 77 to 90 meters (250 to 320 feet) of the San Pedro Formation, and
- Older Tertiary and Miocene sediments.

Locally beneath the coast, Old Hueneme clay deposits are present between the Upper Pleistocene and San Pedro units. The area where those clays may be present includes the northwestern portion of the desktop study area.

The Holocene-age Recent Alluvium and Upper Shelf Deposits are reportedly sandy with lesser amounts of fine-grained (silt and clay) lenticular deposits. The Upper Pleistocene deposits reportedly consist of sand and gravel deposited by the ancestral Santa Clara River and Calleguas Creek drainage systems. The USGS cross-sections interpret formational (bedrock) materials of the marine San Pedro Formation to be present below the Upper Pleistocene deposits (below depths of about 120 to 135 meters [400 to 450 feet]). Although the marine San Pedro formation is considered to be a bedrock formation geologically, this formation typically consists of poorly- or non-cemented fine sands and silts. In geotechnical engineering classification the sands and silts of the San Pedro formation are typically classified as dense granular sediments that may locally include minor cementation.

The interpreted USGS geologic cross sections imply that: 1) geologic sequence and thickness of the individual geologic units is consistent beneath the Oxnard Plain, 2) the lateral continuity and thickness of the geologic units is relatively uniform beneath the project area, and 3) the upper geologic units extend offshore and underlie the Ventura Mainland shelf.

The HDD bore is anticipated to be constructed within the Recent Alluvial geologic unit. The onshore boring drilled on the Southland Sod Farms site in 2005 between the two possible HDD entrance locations penetrated to 61 meters (200 feet) depth. The USGS geologic cross sections suggest that the upper half of that boring penetrated through Recent Alluvium, while the lower half of the boring penetrated submarine shelf deposits. The very dense sand with

gravel encountered at 58 meters (190 feet) depth is interpreted to correspond to the top of the Upper Pleistocene Shelf Deposits.

3.5.4 Subsurface Profiles

The various references and prior Fugro geotechnical studies in the desktop study area include a number of geotechnical borings and Cone Penetration Test (CPT) soundings logs. Those subsurface exploration data have been synthesized to prepare the four subsurface cross-sections shown on Plates 7 through 10. The subsurface profiles also show the depth intervals of the various geologic units as interpreted by the USGS (2003) from water well logs.

Review of geotechnical exploration data from various coastal sites between Port Hueneme and Point Mugu indicate the following general stratigraphic characteristics along this section of the coast:

Onshore Sediment Profile

- Except in areas underlain by historical wetlands and lagoons, the surficial 5 to 10 meters of sediment typically consist of unconsolidated, loose to medium dense silty fine sands.
- In areas where historical wetlands and lagoons were present (refer to the 1917 Soils Map on Plate 5), the surficial 5 to 10 meters of sediment typically consist of soft clays.
- The surficial sediments are typically underlain by a sequence of Recent Alluvial deposits that consists primarily of poorly-graded silty fine sands; these primarily sand sediments:
  - generally extend down to at least El. -30 meters,
  - are typically dense,
  - contain layers of silt and clay within some depth intervals, and
  - include layers that contain gravel and cobbles.
- The Recent Alluvial deposits are underlain by a sequence of layered sands and fine-grained sediments. The subsurface exploration data suggests that these Submarine Shelf Deposits:
  - are more variable than the overlying alluvium,
  - contain more frequent and thicker fine-grained layers than the overlying deposits, and
  - contain layers of sand and gravel, whereas, the overlying alluvium contains less gravel.

Offshore Sediment Profile

- The seafloor sediments within a few kilometers of the coast are characterized as hard silty sand with patches of gravel and scattered rocks.
- Farther offshore the seafloor sediments become more silty.
- The limited amount of factual data indicate that the sampled sediments at the seafloor are typical of the sediments within the first few meters below the seafloor at other locations in the study area along the Ventura Mainland Shelf.

3.6 SEDIMENT CHARACTERISITICS

Laboratory tests of the granular sediments recovered from the onshore drill hole and offshore grab samples, drop cores, and vibracores indicate the granular sediments have the following characteristics:

- Composed of fine sand and coarse silt,
- Fines contents (percent passing the No. 200 sieve) ranging from 25 to 76 percent,
- Mean grain size d_{50}, 0.07 to 0.095mm, and
- Minimal grain sizes larger than a No. 100 sieve.

As shown on Plate A-5, the grain size distribution of the samples from the onshore drill hole are no different than the grain size distribution of the offshore samples.

The laboratory data from the sod farm drill hole and the grab samples are consistent with other locations that Fugro has explored in the desktop study area. Based on our experience in the study area and on our data review, the subsurface conditions encountered at the sod farm and grab sample locations are representative of the alluvial depositional environment of the Oxnard Plain shorefront and are likely representative of conditions that will be encountered at either the proposed Reliant Energy or U. S. Navy HDD optional alignments.

4.0 CONCLUSIONS

To date, one onshore drill hole and several offshore vibracores have been advanced in the general areas of the proposed HDD pipeline shore crossing. Based on correlations with factual subsurface exploration data evaluated in the desktop study area, the subsurface sediments and conditions encountered in those explorations are consistent with the general geologic conditions in the Oxnard Plain beachfront area, inclusive of the proposed pipeline shore crossing area.

The factual preliminary exploration data collected for the HDD shore crossing as well as the regional geologic references and other nearby site-specific geotechnical exploration data all suggest that the entirety of the proposed HDD bores will be within Recent Alluvial Deposits. These deposits underlie the area of the proposed HDD entry locations and extend offshore

beyond the proposed locations of the HDD exits. Whereas, the planned lowest elevation of the HDD bore is -24.4 meters (-80 feet), the geology of the area suggests that the Recent Alluvium extends down to about El -32 meters (-105 feet) along the proposed 1.3-kilometer-long HDD route.

The available exploration data and geologic references suggest the sediments that the HDD bores will pass through consist primarily of very fine silty sand to sandy silt. While layers of fine-grained sediment should be expected, the percentage of the HDD bores that will be within finer-grained layers will probably be relatively minor. The data do not suggest that gravel inclusions will be extensive within the planned HDD bore profile.

Near the HDD bore entry, the desktop data suggest that the conditions at the Reliant Energy site will be similar to the conditions encountered in boring HD-1, drilled in the Southland Sod Farm property. Primarily silty sands are expected to underlie the HDD entry at this location. At the U.S. Navy HDD bore entry location, there is a higher potential that soft clay lagoonal deposits may be encountered within 5 to 10 meters below the ground surface. Future subsurface exploration at that location will confirm whether such deposits are present and provide the required data to engineer the HDD entry.

Construction of the pipeline beneath the shore using HDD techniques appears to be feasible based on the results of this desktop study and on the findings from our preliminary geotechnical study (Fugro West, 2005).

5.0 LIMITATIONS

This desktop geotechnical report has been prepared for the exclusive use of BHP Billiton for input in the CSLC and CCC permitting process for the proposed Cabrillo Port HDD pipeline project. The report may not contain sufficient information for other parties or other uses. Fugro should review any changes in the project, and modify and approve in writing the conclusions and recommendations of this report relative to those changes.

This report and the figures contained in this report are for preliminary planning only, and are not intended for use in final design or construction. Additional geotechnical studies, reports, and services will be needed if the project proceeds to design or construction.

Soil and rock deposits vary in type, strength, and other geotechnical properties between points of observations and exploration. Additionally, ground water and soil moisture conditions vary seasonally or for other man-induced and natural reasons. Therefore, we do not and cannot have complete knowledge of subsurface conditions underlying the site. The criteria presented in this report are based upon findings at the point of exploration and on interpolation and extrapolation of information obtained at the points of observation.

The scope of our services did not include the assessment of the presence or absence of hazardous/toxic substances in the soil, ground water, surface water or atmosphere. Statements

in this report regarding odors or conditions observed are strictly for descriptive purposes and are not intended to convey engineering judgment regarding potential hazardous/ toxic substances.

6.0 REFERENCES

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